



# Evidence Map of Tai Chi

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## PREFACE

Quality Enhancement Research Initiative's (QUERI) Evidence-based Synthesis Program (ESP) was established to provide timely and accurate syntheses of targeted healthcare topics of particular importance to Veterans Affairs (VA) clinicians, managers and policymakers as they work to improve the health and healthcare of Veterans. The ESP disseminates these reports throughout the VA, and some evidence syntheses inform the clinical guidelines of large professional organizations.

QUERI provides funding for four ESP Centers and each Center has an active university affiliation. The ESP Centers generate evidence syntheses on important clinical practice topics, and these reports help:

- develop clinical policies informed by evidence;
- guide the implementation of effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
- set the direction for future research to address gaps in clinical knowledge.

In 2009, the ESP Coordinating Center was created to expand the capacity of HSR&D Central Office and the four ESP sites by developing and maintaining program processes. In addition, the Center established a Steering Committee comprised of QUERI field-based investigators, VA Patient Care Services, Office of Quality and Performance, and Veterans Integrated Service Networks (VISN) Clinical Management Officers. The Steering Committee provides program oversight, guides strategic planning, coordinates dissemination activities, and develops collaborations with VA leadership to identify new ESP topics of importance to Veterans and the VA healthcare system.

Comments on this evidence report are welcome and can be sent to Nicole Floyd, ESP Coordinating Center Program Manager, at [Nicole.Floyd@va.gov](mailto:Nicole.Floyd@va.gov).

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## EVIDENCE MAP OF TAI CHI

### ABSTRACT

This evidence map provides an overview of Tai Chi research and describes its volume and focus. It combines a systematic review of systematic reviews with a scoping review for the VA priority areas pain, posttraumatic stress disorder, and fall prevention. The evidence map summarizes patient outcomes reported in reviews of studies in patients practicing Tai Chi for health-related indications. We searched PubMed, DARE, the Cochrane Library of Systematic Reviews, the Campbell Collaboration database, AMED, CINAHL, PsycInfo, Scopus, Web of Science, and PROSPERO; screened reviews of reviews; and consulted with topic experts. We used a bubble plot to graphically display the research field and summarized results narratively in an executive summary.

Tai Chi has been investigated as a treatment for a number of clinical indications. The systematic review identified 107 systematic reviews. Reviews addressing general health effects, psychological wellbeing, or interventions in older adults included between 31 and 51 randomized controlled trials (RCTs). The topic areas balance, hypertension, falls, quality of life, cognitive performance, and vestibulopathy have also been the focus of research; included reviews identified 10 or more pertinent RCTs per topic. Statistically significant effects across existing studies were reported for hypertension, falls outside of institutions, cognitive performance, osteoarthritis, chronic obstructive pulmonary disease, pain, balance confidence, depression, and muscle strength. However, review authors cautioned that firm conclusions cannot be drawn due to methodological limitations in the original studies and/or an insufficient number of research studies.

### BACKGROUND

Many Veterans desire complementary and alternative medicine or integrative medicine modalities, both for treatment and for the promotion of wellness. Given the VA's desire to promote evidence-based practice, this evidence mapping project aims to help provide guidance to VA leadership about the distribution of evidence about Tai Chi to inform policy and clinical decision making.

Tai Chi, also known as T'ai chi ch'uan or Taijiquan, developed as an ancient Chinese martial art and today is widely practiced for its health benefits. Many forms of Tai Chi exist, but in Western culture, it is most commonly taught as a series of slow, gentle, low-impact movements that integrate the breath, the mind, and physical activity to achieve greater awareness and a sense of inner peace and well-being.<sup>1</sup> Tai Chi incorporates the Chinese concepts of yin and yang, which represent two opposing yet complementary forces described in traditional Chinese medicine. The underlying premise is that good health is achieved by balancing these opposing forces. Tai Chi is designed to strengthen and stretch the body, improve the flow of blood and other fluids throughout the body, and improve balance, proprioception and awareness of how the body moves through space. It may be practiced in a group format or alone. Results from the 2007 National Health Interview Survey – a national survey conducted on a representative sample of adults in the US – estimates that approximately 2.3 million adults in the U.S. had practiced Tai Chi in the

past 12 months.<sup>2</sup> There is no official licensure granted by national or state professional boards, and there are no official standards for training instructors. Rather, students are taught by a master, and then teach with the master's approval. Thus, training programs vary.

## KEY QUESTIONS/SCOPE OF PROJECT

The project deliverables are:

- An Evidence Map that provides a visual overview of the distribution of evidence (both what is known and where there is little or no evidence base) for Tai Chi; and
- A set of executive summaries that would help stakeholders interpret the state of the evidence to inform policy and clinical decision making.

## METHODS

This project provides an overview of the existing research evidence on Tai Chi. It combines a systematic review of systematic reviews with a scoping review for VA priority areas.

The systematic review of systematic reviews is registered in PROSPERO, an international database of prospectively registered systematic reviews in health and social care (record number CRD42014009907). Systematic reviews follow a standardized and resource-intensive approach that aims to identify all critical studies to answer a particular research or policy question. Systematic reviews provide estimates of the research volume identified in multiple sources. Studies included in systematic reviews may be synthesized in a meta-analysis, a statistical technique to pool data across studies, which can detect treatment effects across individual small and underpowered studies. Given the breadth of the research field, broad indications of the clinical effect are based on results of RCTs, a rigorous research design which can provide strong evidence for the effectiveness of Tai Chi.

The primary client and technical expert panel (TEP) determined the outcomes and clinical indications pain, posttraumatic stress disorder (PTSD), and fall prevention to be VA priority areas. The published literature continues to grow and new RCTs may challenge existing summaries of the literature. Hence we have identified recently published RCTs not yet included in published systematic reviews for priority areas. In the absence of RCTs, other research designs were considered.

## INCLUSION CRITERIA

To be included in the evidence map, publications had to meet the following criteria:

- **Design:** Systematic reviews focusing on Tai Chi and summarizing primary research studies were eligible for inclusion for all clinical indications. We defined systematic reviews as reviews that either self-identified as a “systematic review” or reviews that reported the search sources and accounted for identified studies. For the VA priority areas, recent RCTs focusing on Tai Chi, reporting patient outcomes, and not yet included in existing reviews were also reviewed and other research designs were considered in the absence of RCTs.
- **Participants:** Systematic reviews including human adult participants practicing Tai Chi for any health-related indication were eligible for inclusion in the evidence map. Systematic reviews of adult participants or unspecified age groups were included; systematic reviews exclusively focusing on children and adolescents were excluded.
- **Intervention:** Systematic reviews of the effects of Tai Chi for any clinical indication were eligible for inclusion. Systematic reviews addressing Tai Chi and other approaches were eligible if one of the two following criteria was met: (1) the term “Tai Chi” was part of the search strategy, or (2) the search strategy did not specify any interventions (*eg*, focused on an outcome) and the systematic review identified Tai Chi studies. We excluded systematic reviews that included Tai Chi studies but did not systematically search for these (*eg*, by reviewing “exercise” interventions where only those Tai Chi

studies were found that used the descriptive term “exercise”), and broad reviews on complementary and alternative medicine approaches without particular focus on Tai Chi.

- Outcome: Patient health outcomes were eligible for inclusion. Systematic reviews of provider outcomes, acceptance, prevalence, use, costs, study design features, or intervention features not reporting patient health outcomes were excluded.
- Timing: Systematic reviews including any intervention duration and any followup point were eligible for inclusion.
- Setting: Systematic reviews of studies in healthcare-related settings were eligible for inclusion.
- English-language systematic reviews, regardless of the language of the included studies were eligible for inclusion. VA priority areas were searched without language restriction.

## SEARCH

We searched the electronic databases PubMed using the systematic review clinical query; the Database of Abstracts of Reviews of Effects (DARE, a database dedicated to catalogue systematic reviews in healthcare); the Cochrane Library of Systematic Reviews (which keeps a record of all ongoing and completed Cochrane reviews); the Campbell Collaboration database; AMED (the Allied and Complementary Medicine database); CINAHL (which indexes nursing and allied health literature); PsycInfo (which is directed at psychological research), Scopus and the Web of Science (to capture sports literature), and the review registry PROSPERO without publication date restriction, to identify English-language systematic reviews focusing on Tai Chi published to February 2014. In addition, we screened published reviews of reviews and consulted topic experts.

In order not to miss any publications because of different spelling conventions, we used the terms “tai chi,” “tai-chi,” “tai ji,” “tai-ji,” “taiji,” “t ai chi,” “t ai chi,” “taijiquan,” and “shadow boxing.”

We also searched PubMed for Tai Chi RCTs, using the RCT search filter, without language restriction to identify recently published RCTs reporting on the outcome pain and/or falls, not yet included in existing systematic reviews. We searched PubMed, AMED, CINAHL, PsycInfo, Scopus, and the Web of Science without date, language, or study design restriction to identify PTSD publications not yet included in existing systematic reviews.

## PROCEDURE

Two independent literature reviewers screened the systematic review search output. Citations deemed potentially relevant by at least one reviewer and unclear citations were obtained as full text. The full text publications were screened against the specified inclusion criteria by 2 independent reviewers; disagreements were resolved through discussion. The literature flow was documented in an electronic database and reasons for exclusion of full text publications were recorded. Results of individual reviews and recent RCTs were extracted in an online database for systematic reviews.

We removed data duplicates so that each systematic review entered the dataset only once (this entailed consolidating online-only and final publication of articles, Cochrane reviews published

in the Cochrane database and in a journal article, multiple updates of Cochrane reviews, and references to systematic reviews differently indexed in general and specialist systematic review databases). Where originals and updates of systematic reviews by the same author group were available, only the most recent version was considered.

The search results of the scoping review for VA priority areas was screened in duplicate and the literature flow was documented in an electronic database.

## DATA SYNTHESIS

We provide a general overview of the Tai Chi literature by mapping systematic review results and a more detailed research overview for the 3 priority areas pain, PTSD, and fall prevention.

From each included systematic review, we extracted the specific clinical indication targeted in the review (*eg*, osteoarthritis) and the main patient outcomes (*eg*, pain) that were summarized across included studies. We extracted the number of Tai Chi RCTs included in the review, the comparator, and treatment effect estimates for patient outcomes. Pooled results were extracted as reported; results were not reanalyzed. Additionally, we extracted review characteristics such as whether the review was a Cochrane review, indicating methodological rigor. We also extracted whether adverse events had been addressed, and documented which reviews were based on a format of Tai Chi that deviated from traditional formats (*eg*, no weight shifting component; water-based; sitting, not standing; limited training intensity).

### Bubble plots

The evidence base of Tai Chi research was distilled into a visual overview using the format of bubble plots. Bubble plots use color to differentiate clinical indications and provide 3 dimensions to display information: the x-axis, y-axis, and the size of the bubble.

**Clinical indications (number of bubbles):** We used the topics of the individual systematic reviews as reported by the review authors to categorize the systematic reviews. Reviews focused on outcomes, populations, or clinical indications. All identified systematic reviews were allocated to a single content area and did not enter the bubble plot multiple times. Where reviews provided data for multiple content areas, results were described in the narrative synthesis.

**Literature size (y-axis):** The bubble plots provide an overview of the research volume or quantity for the identified clinical indications. For this estimate we used the number of included RCTs per review, selecting the systematic review with the most included Tai Chi RCTs for the individual topic as the research volume estimate. Reviews vary in their inclusion criteria for study designs (*eg*, whether or not they include observational studies). A well-established research design, such as RCTs, that is always likely to be included in reviews, provides a broad estimate of the research volume.

**Effect (x-axis):** The bubble plots provide a very broad indication of the clinical effectiveness of Tai Chi according to patient health outcomes reported in RCTs for each differentiated clinical indication. For each clinical topic, all available systematic reviews were reviewed. Most emphasis was given to the largest review (which should provide the most complete literature synthesis), Cochrane reviews (given their methodological quality), or reports from agencies

specializing in unbiased systematic reviews such as the Agency for Healthcare Research and Quality (AHRQ). For effect size estimates, meta-analytic results were sought to provide a summary effect across individual and often small and underpowered studies.

**Reviews (bubble size):** We used the size of the bubble to document the number of systematic reviews identified in the systematic review of systematic reviews on Tai Chi.

## Executive Summary

While the bubble plot can display only very limited information, the narrative synthesis in the executive summary provides more detailed information on the individual clinical indications, outcomes, treatment effect estimates, individual reviews, and included studies.

We differentiated areas with most research, areas with a smaller research base, and most promising areas, and provided more detailed information for each of the a priori identified priority areas.

## Future Research

We identified evidence gaps by documenting topic areas for which systematic reviews exist but the reviews did not identify relevant RCTs (*ie*, high evidence level research studies). In addition, we documented clinical indications for which there is conflicting evidence across identified reviews or where reviews concluded that the existing evidence base is insufficient to come to firm conclusions.

We also documented ongoing systematic reviews registered in review registries that will become available to summarize a topic area in the near future. We identified Cochrane review protocols published in the Cochrane Database of Systematic Reviews in last 3 years and not yet published as a review, indicating an ongoing review. PROSPERO, the international registry of systematic reviews, was also searched to identify ongoing systematic reviews on Tai Chi.

## TECHNICAL EXPERT PANEL

The technical expert panel (TEP) for the project included Stephen Ezeji-Okoye, MD, VHA Central Office Field Advisory Committee on Complementary and Alternative Medicine; Laura Krejci, Associate Director VA Office of Patient Centered Care and Cultural Transformation; Peter Asco, Therapy Assistant, Tai-Chi and Qi Gong Instructor at University of California Los Angeles and Tai Chi Program Developer; Ansgar Furst, PhD, MSc, Clinical Assistant Professor of Psychiatry and Behavioral Sciences and of Neurology & Neurological Sciences, Stanford University School of Medicine, Associate Director of Neuroimaging, War Related Illness and Injury Study Center, VA Palo Alto Health Care System; Laura Redwine PhD, Assistant Professor of Psychiatry University of California San Diego, Research Scientist Veterans Medical Research Foundation San Diego; Greg Patterson PhD, HSPP, Clinical Psychologist Oscar G. Johnson VA Medical Center; and Elmer Ligh MPT, Physical Therapist at Hunter Holmes McGuire Veterans Hospital in Richmond, Virginia.

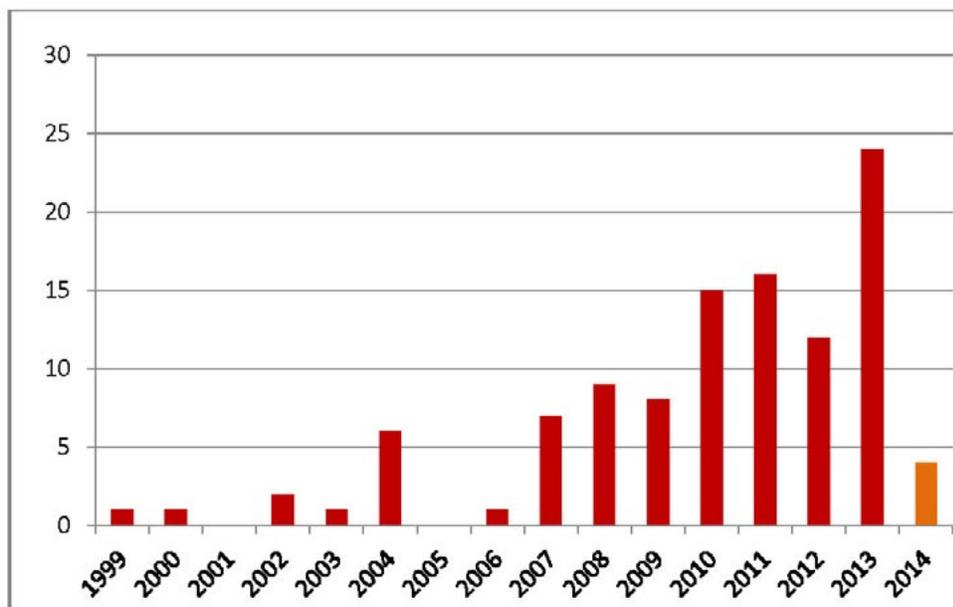
## PEER REVIEW

A draft version of the deliverable was reviewed by both technical experts and clinical leadership. Reviewer comments were incorporated in the final report and are documented in the appendix.

## RESULTS

The systematic review of systematic reviews identified 321 citations. This included 107 unique systematic reviews meeting the inclusion criteria.<sup>1,3-108</sup> One potentially relevant publication could not be obtained for inclusion screening.<sup>109</sup> The figure shows the number of included systematic reviews summarizing Tai Chi research by year.

**Figure 1: English-language systematic reviews on Tai Chi published to February 2014**

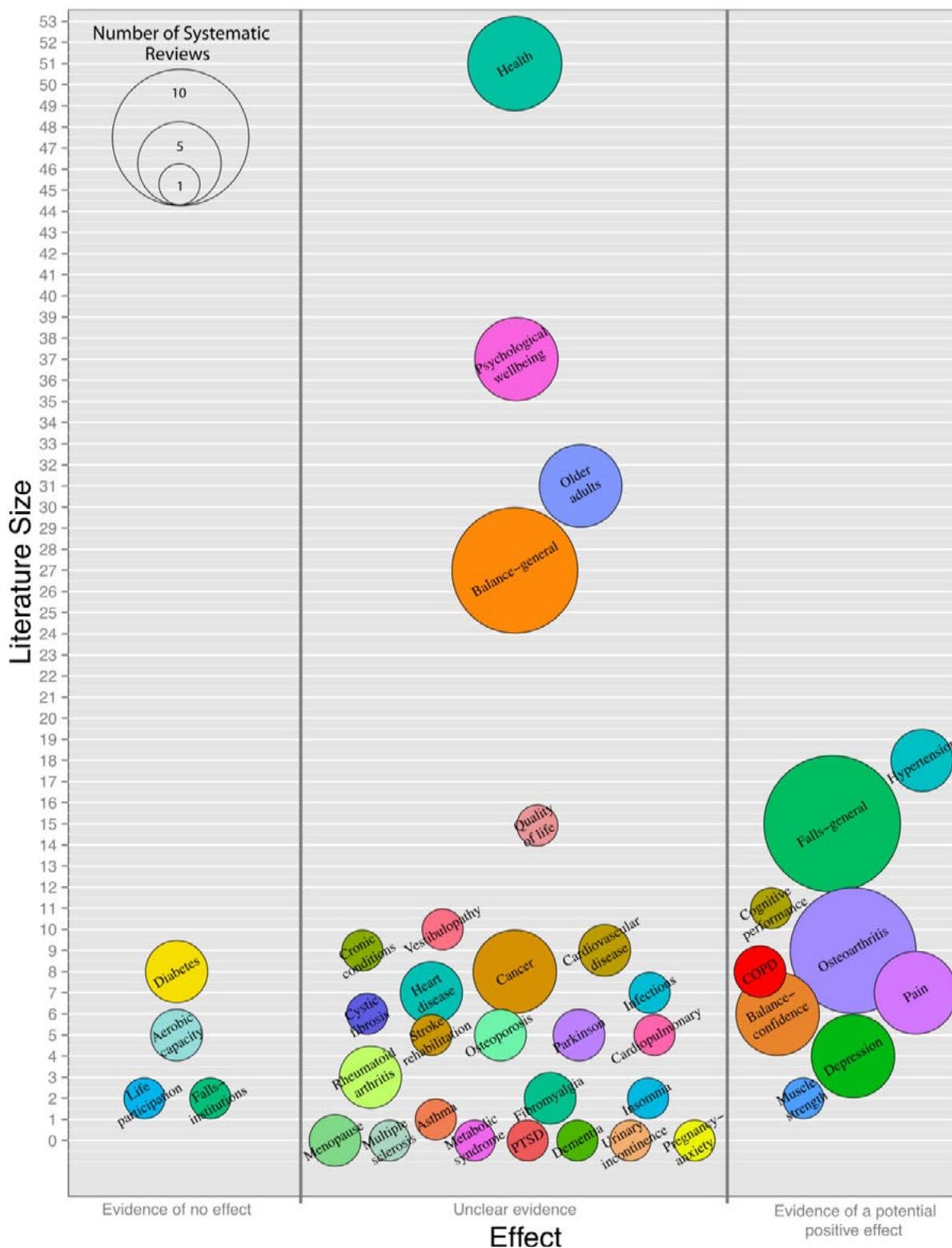


Most of the 107 included systematic reviews were published in the last 4 years with a current peak in 2013. The number of published systematic reviews is increasing, for example from 0 to 2 reviews published each year from 1999 to 2006 (excluding 2004) to 7 to 24 reviews published per year from 2007 onwards. The 2014 column is not informative because searches were performed in February and complete statistics for 2014 are not known. We excluded earlier versions of reviews and only retained the latest update of the systematic review in the dataset; however, excluded earlier versions had been published in the years 2008 to 2010, not earlier.

## EVIDENCE MAP OF TAI CHI

The results are presented in a bubble plot and a text summary. The bubble plot summarizes the results of all identified systematic reviews for distinct clinical indications.

Figure 2: Evidence Map of Tai Chi February 2014



The bubble plot summarizes Tai Chi systematic reviews published to February 2014 and depicts the clinical conditions addressed in reviews (bubbles), the estimated size of the literature (y-axis), the effectiveness trend according to reviews (x-axis), and the number of systematic reviews (bubble size) per clinical condition.

The evidence map used the clinical topics addressed in existing systematic reviews. Primary research studies may have contributed to more than one included systematic review. Studies included in the evidence map varied widely in the style of employed Tai Chi, the intervention duration, and intervention intensity, but none of the effects was primarily based on studies where Tai Chi was only a component of the overall intervention, or the effect was based on studies using a nontraditional format such as water-based Tai Chi. Of the included reviews, 58% did not address adverse events, 7% addressed adverse events but did not report on specific adverse events in the included studies, and 35% reported on the presence or absence of adverse events. All depicted dimensions in the bubble plot are estimates of the evidence base and can provide only a broad overview.

## EXECUTIVE SUMMARY

### Areas with the Largest Research Base

Most research, defined as clinical areas with at least 10 identified RCTs in the largest review, was included in general overviews that addressed general health benefits, psychological wellbeing, or the effect of Tai Chi in older adults. Six systematic reviews were identified that have addressed **health** benefits of Tai Chi<sup>10,15,31,50,55,74</sup> and the largest review included 51 Tai Chi RCTs. The largest review, a comprehensive review of health benefits of qigong and Tai Chi, did not provide treatment effect estimates across individual studies but concluded that research has demonstrated consistent, significant results for a number of health benefits in RCTs, evidencing progress toward recognizing the similarity and equivalence of qigong and Tai Chi.<sup>50</sup> Health benefits were also addressed in a 2007 AHRQ report on meditation practices which included 29 Tai Chi RCTs, in the majority rated poor quality.<sup>14</sup> Results of individual studies and pooled results across clinical areas and outcomes varied. The other systematic reviews, addressing Tai Chi or movement therapy as a nursing intervention, effects of martial arts on health status, therapeutic benefits of Tai Chi, or Tai Chi Chuan as a mind-body practice or exercise intervention, primarily highlighted the need for more research. Five systematic reviews concentrated on **psychological wellbeing**<sup>1,19,27,51,106</sup> and the largest included 37 RCTs. The largest review pooled only 3 of the included RCTs and reported positive effects of Tai Chi compared to wellness education and stretching for depression (mean difference [MD] -5.97, 95% confidence interval [CI] -7.06, -4.87).<sup>19</sup> A meta-analysis reported positive pooled results for stress (Hedges' g 0.97; 95% CI 0.06, 1.87; 4 RCTs) and depression (Hedges' g 0.48; 95% CI 0.17, 0.78; 9 RCTs), but not anxiety or mood outcomes, associated with Tai Chi compared to a variety of comparators.<sup>1</sup> A further review concluded it is premature to form conclusions on the effect of Tai Chi on psychological wellbeing. Two further reviews concluded psychological benefits without providing specific treatment estimates, but highlighted no superiority of Tai Chi compared to other low to moderate intensity activities. Four reviews addressed interventions in **older adults**<sup>80,81,90,108</sup> and the largest included 31 RCTs. Three of the reviews did not target particular outcomes; instead they reviewed clinical trials of Tai Chi and qigong in older adults (defined as older than 55), perceived benefits of meditative movements in older adults (defined as older than 65), or the efficacy of Tai Chi Chuan in older adults (defined as older than 50). One review addressed exercise and mental wellbeing in older adults (defined as 65 or older). The largest review combined Tai Chi and qigong<sup>81</sup>; none of the reviews reported specific treatment effects of Tai Chi across studies.

The outcome **balance** has been addressed in 9 systematic reviews by independent author groups<sup>4,32,34,48,52,57,68,73,104</sup> and the largest included 27 RCTs. The largest review concluded that studies appear to confirm that Tai Chi improves static and dynamic balance but did not provide specific treatment effect estimates.<sup>52</sup> A Cochrane review on exercise interventions for improving balance in older people included 12 Tai Chi RCTs; individual study results varied and pooled results were only reported for a combination of Tai Chi, Gi Gong, dance, and yoga interventions studies.<sup>48</sup> One review pooled 3 RCTs and found no effect of Tai Chi on the Single Leg Stance test compared to different control groups.<sup>4</sup> Results of studies included in the remaining reviews varied and none of the reviews provided a treatment effect estimate across identified studies.

The outcome **hypertension** has been addressed in 3 systematic reviews<sup>64,92,101</sup> and the largest included 18 RCTs. The largest review (published in 2013) reported statistically significant effects in favor of Tai Chi compared to routine care for a combined effectiveness outcome in lowering blood pressure (relative risk [RR] 3.39; CI 1.81, 6.34; 4 RCTs), systolic (weighted mean difference [WMD] -12.43; CI -1262, -12.24; 10 RCTs), and diastolic blood pressure (WMD -6.03; CI 6.16, -5.90; 10 RCTs), but the review cautioned that due to poor methodological quality, the evidence remains weak. A 2010 review that included 4 RCTs concluded the evidence for Tai Chi in reducing blood pressure in the elderly is limited<sup>64</sup> and the other review did not provide pooled treatment estimates across studies due to study heterogeneity. Tai Chi in **fall prevention** using unselected studies or populations living in the community has been addressed in 10 independent reviews<sup>11,14,38,40,42,43,46,69,71,83,96</sup> and the largest included 15 RCTs. The largest review reported no benefit of Tai Chi compared to non-exercise controls across 5 studies but a significant pooled estimate for Tai Chi versus exercise controls (incidence rate ratio [IRR] 0.51; 95% CI 0.38, 0.68; 2 RCTs).<sup>69</sup> A Cochrane review on interventions for preventing falls in older people living in the community found no reduction in the rate of falls across 5 RCTs but a significantly reduced risk of falling (RR 0.71; 95% CI 0.57, 0.87; 6 RCTs) associated with Tai Chi compared to diverse, predominantly passive comparators (*eg*, wellness education).<sup>42</sup> An AHRQ report on interventions to prevent falls in older adults included 3 Tai Chi studies but results were inconsistent and no pooled effect was reported.<sup>14</sup> A systematic review on fall prevention that included 6 Tai Chi RCTs gave the pooled estimate for community dwelling studies as RR 0.66 (95% CI 0.52, 0.78; comparators not specified) but found no effect for residential aged-care facility studies.<sup>11</sup> One review found no Tai Chi fall prevention study in older persons with cognitive impairment; the remaining reviews showed conflicting results across studies and did not provide a pooled effect estimate. Some reviews primarily addressing balance also reported on the outcome falls. One of these pooled the available data on falls and found no statistically significant results for Tai Chi.<sup>4</sup>

A systematic review that specifically addressed the outcome health-related **quality of life** across Traditional Chinese Medicine interventions included 15 Tai Chi RCTs.<sup>23</sup> The review did not provide a summary estimate for Tai Chi effects and individual study results varied within and across studies. The outcome was also assessed in several other systematic reviews: positive effects were reported for patients with COPD<sup>99</sup> and disease-specific quality of life in chronic heart failure patients;<sup>103</sup> conflicting results across outcomes and across studies were reported for patients with osteoarthritis of the knee<sup>59</sup> and musculoskeletal pain conditions;<sup>44</sup> and no superiority compared to control interventions was found for cancer<sup>60,75</sup> and diabetes care,<sup>18,61</sup> as described below in more detail.

One systematic review addressed the effects of Tai Chi on **cognitive performance** in older adults and identified 11 relevant RCTs.<sup>95</sup> The review found a large effect of Tai Chi in executive function in cognitively healthy adults compared to no intervention (Hedges'  $g$  0.90;  $p=0.04$ ; 4 RCTs), a moderate effect compared to exercise (Hedges'  $g$  0.51;  $p=0.003$ ; 2 RCTs), smaller but statistically significant effects of global cognitive function in cognitively impaired adults compared with nonintervention controls (Hedges'  $g$  0.35;  $p=0.004$ ; 4 RCTs) and other active interventions (Hedges'  $g$  0.30;  $p=0.002$ ; 4 RCTs), but cautioned that larger and methodologically sound trials with longer followup periods are needed before definitive conclusions can be drawn.

One systematic review was identified that addressed the role of Tai Chi in **vestibulopathy** and it included 10 RCTs addressing a variety of outcomes.<sup>94</sup> None of the included studies were in patients with a diagnosis of vestibular disease and the review concluded that more research is needed into the mechanism whereby Tai Chi can remedy balance disorders.

### Areas with a Smaller Research Base

Fewer research studies (*ie*, fewer than 10 RCTs identified in existing systematic reviews) are available for a large number of addressed clinical indications and outcomes.

Eight systematic reviews have addressed **osteoarthritis**<sup>6,16,25,39,53,59,84,86,98,110</sup> and the 2 largest reviews included 9 RCTs each. Of the 2 largest reviews, one reported positive effects of Tai Chi compared to different control groups on pain (standard mean difference [SMD] -0.79; 95% CI -1.19, -0.39;  $p<0.001$ ; 6 RCTs), physical function (SMD -0.86; 95% CI -1.20, -0.52;  $p<0.001$ ; 6 RCTs), and joint stiffness (SMD -0.53; 95% CI -0.99, -0.08;  $p=0.02$ ; 6 RCTs), but the review cautioned that due to the small number of RCTs with a low risk of bias, the evidence that Tai Chi is effective in patients with osteoarthritis is limited.<sup>53</sup> The other large review did not report a numerical pooled treatment effect estimate, but a review specific to functional aerobic capacity in lower limb osteoarthritis by the same author group found significant improvements associated with Tai Chi (effect size [ES] 0.66; 95% CI 0.23, 1.09; 3 RCTs; 6-minute walk test) compared to education or no intervention.<sup>25</sup> An independent review reported significant positive short-term effects of Tai Chi compared to waitlist or attention control for pain intensity (SMD -0.72; 95% CI -1.00, -0.44; 5 RCTs), function (SMD -0.72; 95% CI -1.01, -0.44; 5 RCTs), stiffness (SMD -0.59; 95% CI -0.99, -0.19; 5 RCTs), and physical quality of life (SMD 0.88; 95% CI 0.42, 1.34; 2 RCTs), but not for mental quality of life or long-term effects for pain, physical function, and stiffness (2 RCTs per comparison). The review highlighted that all positive results represent short-term effects and high quality RCTs are needed to confirm the results.<sup>59</sup> A further osteoarthritis review and meta-analysis reported statistically significant effects compared to different control groups for pain (SMD -0.45; 95% CI -0.70, -0.20; 7 RCTs), stiffness (SMD -0.31; 95% CI -0.60, -0.02; 5 RCTs), and physical function (SMD -0.61; 95% CI -0.85, -0.37; 5 RCTs) and concluded that 12-week Tai Chi should be included in rehabilitation programs but that the evidence may be limited by potential biases.<sup>98</sup> Two reviews did not identify any eligible Tai Chi RCTs and the remaining reviews did not report treatment effects across individual studies.

**Cardiovascular disease** has been the topic in 2 systematic reviews; both included 9 RCTs each.<sup>13,100</sup> Reviews addressed a number of conditions and risk factors. Individual study results varied across outcomes and clinical indications and both reviews concluded that further research is needed. One review addressed the role of Tai Chi in **chronic conditions** and included 9

RCTs.<sup>91</sup> Results of individual studies varied and the review concluded that it is difficult to draw firm conclusions. Tai Chi in **cancer** care has been evaluated in 5 systematic reviews<sup>22,30,60,66,75</sup> and the largest included 8 RCTs. The largest review found positive pooled effects for the outcome vitality (MD 1.56; 95% CI 0.60, 2.51; 2 RCTs) and mental health (MD 2.38; 95% CI 1.75, 3.01; 2 RCTs) compared to standard care or support group but not for the SF-36 quality of life domains physical functioning, bodily pain, role physical, general health, social functioning, or role emotional (2 RCTs per comparison).<sup>22</sup> A Cochrane review of health-related quality of life for cancer survivors included one Tai Chi RCT and reported no statistically significant effects of Tai Chi compared to walking.<sup>75</sup> A review on exercise interventions for cancer-related fatigue among adult cancer survivors included the same Tai Chi study; it did not report statistically significant effects on fatigue. One review found no statistically significant effects of Tai Chi compared to a walking exercise, psychosocial support, or spiritual growth and standard health care on quality of life across 3 studies and concluded that the existing trial evidence does not show convincingly that Tai Chi is effective for supportive breast cancer care.<sup>60</sup> The author group came to the same conclusion in a review on adjunct cancer care not limited to breast cancer.<sup>66</sup>

Tai Chi in type 2 **diabetes** has been addressed in 3 systematic reviews<sup>18,20,61</sup> and the largest included 8 RCTs. The largest review meta-analyzed fasting blood glucose, glycosylated hemoglobin A1c, and quality of life (various comparators) and concluded that the existing evidence does not suggest that Tai Chi is an effective therapy for type 2 diabetes.<sup>61</sup> A more recent systematic review (published in 2013) included 4 RCTs and also did not find statistically significant effects across studies on fasting blood glucose, hemoglobin A1c, and insulin resistance (compared to aerobic exercises, free activity program, waitlist, or sham exercise), and concluded a lack of Tai Chi related effects in patients with type 2 diabetes.<sup>20</sup> A review on effects of exercise on quality of life, depression, anxiety, and emotional well-being in type 2 diabetes included 2 Tai Chi RCTs; both were included in the 2013 review and reported no significant between-group differences.<sup>18</sup>

Two systematic reviews have investigated Tai Chi for chronic obstructive pulmonary disease (**COPD**)<sup>37,99</sup> and the largest included 8 RCTs. The largest review reported significant pooled effects of Tai Chi on the 6-minute walk test (WMD 34.22 m; 95% CI 21.25, 47.20; 3 RCTs), dyspnea (WMD -0.86 units; 95% CI -1.44, -0.28, 3 RCTs), forced expiratory volume in 1 second (FEV1; WMD 70 ml; 95% CI 0.02, 0.13, 4 RCTs), forced vital capacity (FVC; WMD 120 ml; 95% CI 0.00, 0.23, 3 RCTs), and 2 quality of life measures (WMD 0.95; 95% CI 0.22, 1.67; 2 RCTs; WMD -4.08; 95% CI -7.52, -0.64; 3 RCTs); the control intervention was not specified.<sup>99</sup> The second review combined Tai Chi and qigong interventions and did not provide treatment estimates across Tai Chi studies. A review on asthma and COPD (described further below) included 4 RCTs but did not report a pooled treatment estimate. Four systematic reviews have focused on the outcome **pain**<sup>44,77,102,107</sup> and the largest review included 7 RCTs including 6 arthritis studies. The largest review found a positive effect of Tai Chi on self-reported pain (MD 10.1 points on a 0-100 scale; 95% CI 6.3, 13.9; 6 RCTs; comparators not specified). The review also found a positive effect on self-reported disability (MD -9.6; 95% CI -14, -5.2; 4 RCTs) but not physical performance, and data for quality of life were not pooled across studies.<sup>44</sup> Results of individual studies included in 2 other reviews varied and no treatment estimate of Tai Chi was reported while one found no eligible Tai Chi RCT. The outcome pain was addressed in several included systematic reviews. Three reviews on osteoarthritis reported statistically significant

effects on pain (SMD -0.45; 95% CI -0.70, -0.20; 7 RCTs;<sup>98</sup> SMD -0.79; 95% CI -1.19, -0.39; 6 RCTs;<sup>53</sup> SMD -0.72; 95% CI -1.00, -0.44; 5 RCTs<sup>59</sup>) but cautioned that the evidence base is limited and/or results are limited to short-term effects. The Cochrane review on rheumatoid arthritis did not find statistically significant differences in joint tenderness associated with Tai Chi across 2 studies.<sup>45</sup>

One systematic review analyzed the effect of Tai Chi on immunity and **infections** and included 7 RCTs.<sup>47</sup> Results varied by outcome and the overall treatment effect was not reported. Three reviews focused on **heart disease**<sup>35,78,103</sup> and the largest included 7 RCTs. There was little overlap between studies included in the general cardiovascular disease reviews and those contributing to the heart disease-specific reviews. Two of the heart disease reviews reported conflicting results regarding the effectiveness of Tai Chi in included studies and did not provide an overall treatment effect estimate. The third review reported no reduction in N-terminal pro brain natriuretic peptide, systolic blood pressure, diastolic blood pressure, improved 6-minute walk test, or peak oxygen uptake but reported statistically significant results for quality of life in chronic heart failure patients (WMD -14.54, 95% CI -23.45, -5.63; 3 RCTs).

Five systematic reviews focused on the outcome **balance confidence** or fear of falling<sup>9,12,28,79,87</sup> and the largest included 6 RCTs. The largest review did not report a treatment effect estimate across studies.<sup>9</sup> A further review that included 5 Tai Chi RCTs among other interventions reported a positive pooled effect on balance confidence for Tai Chi compared to usual care, exercise, or education (SMD 0.47; 95% CI 0.30, 0.63; 4 RCTs).<sup>79</sup> Two other systematic reviews on balance confidence and fear of falling included Tai Chi studies and concluded that Tai Chi seems beneficial but did not provide a treatment estimate across studies. One review on the impact of fear of falling in long-term care included a Tai Chi study; fear of falling, operationalized as a one-item question, did not differ across groups.

A systematic review on **cystic fibrosis** included 6 Tai Chi RCTs.<sup>70</sup> Individual study results varied and no conclusions regarding an overall treatment effect of Tai Chi was reported. The role of Tai Chi in **Parkinson's disease** has been addressed in 2 independent reviews<sup>17,62</sup> and the largest included 5 RCTs. Both reviews did not report an overall treatment effect and concluded that the evidence is insufficient to suggest Tai Chi is an effective intervention for Parkinson's disease. Two systematic reviews have addressed **osteoporosis**<sup>67,93</sup> and the largest review included 5 RCTs. Results of individual studies included in the largest review varied by study and outcome; the only pooled estimate (bone mineral density at the spine, 4 RCTs) indicated no effect compared to no treatment in postmenopausal women.<sup>67</sup> An earlier systematic review that included 2 RCTs concluded that Tai Chi may be effective but no treatment effect estimates were reported. One review addressed **stroke rehabilitation** and identified 5 RCTs.<sup>111</sup> No meta-analysis was performed due to heterogeneity of conditions and outcomes and individual study results varied. One review summarized **cardiopulmonary** physiotherapeutic applications of Tai Chi and identified 5 relevant RCTs.<sup>56</sup> The review did not report treatment effect estimates.

Two reviews investigated the effects of Tai Chi on **aerobic capacity**<sup>63,88</sup> and the largest review included 5 RCTs. Both reviews showed no significant effect on peak oxygen uptake or maximal oxygen consumption across studies and the largest review concluded that the existing evidence does not suggest that regular Tai Chi is an effective way of increasing aerobic capacity.<sup>63</sup> Aerobic

capacity was also addressed in 2 other reviews; a review in osteoarthritis patients selected the 6-minute walk test as a functional aerobic capacity test and found positive results<sup>25</sup>; a review on heart disease patients did not find effects on the 6-minute walk test or peak oxygen uptake.<sup>103</sup>

Five systematic reviews have specifically addressed the effects of Tai Chi on the outcome **depression**.<sup>21,29,33,89,97</sup> the largest review included 4 RCTs, and a review of psychological wellbeing included 9 RCTs reporting on depression. The largest depression-specific review (published in 2012) reported significantly reduced depression symptoms (SMD -0.27; 95% CI -0.52; -0.02; 4 RCTs) compared to waitlist control across studies in older adults but highlighted that further research is recommended with larger samples sizes, more clarity on trial design and the intervention, longer-term followup, and concomitant economic evaluations.<sup>33</sup> The general overview on Tai Chi and psychological wellbeing also reported a positive effect on depression (Hedges' g 0.48; 95% CI 0.17, 0.78); this earlier review included 9 RCTs in total, which includes 3 of the 4 RCTs reviewed in the largest depression-specific review.<sup>1</sup> The other depression-specific reviews included only one or two Tai Chi studies or did not distinguish effects attributable to Tai Chi. As previously described, one other psychological wellbeing review included a statistically significant positive result of Tai Chi for depression compared to wellness education and stretching (MD -5.97, 95% CI -7.06, -4.87; 3 RCTs).<sup>19</sup>

**Rheumatoid arthritis** has been addressed in 3 systematic reviews<sup>45,65,72</sup> and the largest included 3 RCTs. The largest review is a Cochrane review but it has not been updated since 2004. It concluded that Tai Chi does not exacerbate symptoms and that there are benefits for lower extremity range of motion, but not for most outcomes of disease activity, including activities of daily living, tender and swollen joints, and patient global ratings.<sup>45</sup> A second review included one, not statistically significant, RCT, and a further review found conflicting results across studies and concluded that collectively the evidence is not convincing enough to suggest that Tai Chi is an effective treatment for rheumatoid arthritis.<sup>65</sup> Two reviews summarized evidence of Tai Chi effects on **fibromyalgia**<sup>58,76</sup> and both included 2 RCTs. Both reviews reported results across meditative movement or complementary and alternative exercise interventions and did not provide summary treatment effect estimates for Tai Chi specifically or pooled results across a number of study designs. One review on **insomnia** included 2 Tai Chi RCTs.<sup>82</sup> The review indicated that both trials were positive on a variety of Pittsburgh Sleep Quality Index measures but the statistical significance was not reported.

A systematic review on the effects of Tai Chi on lower-limb **muscle strength** in the elderly included 2 RCTs.<sup>5</sup> Both RCTs showed positive effects but did not report on the same outcome and were not combined to estimate the overall treatment effect.

A Cochrane review on interventions for preventing falls in older people in care facilities and hospitals (**falls-institutions**) included 2 Tai Chi studies, both reporting no significant difference in risk of falling associated with Tai Chi.<sup>3</sup> The result was also found by an independent review group.<sup>11</sup> One review addressed the question of whether exercise interventions designed to prevent falls affect participation in life roles (**life participation**) and included 2 Tai Chi RCTs.<sup>40</sup> Both included RCTs did not show statistically significant effects of Tai Chi compared to usual care.

A review on Tai Chi for **asthma** and COPD identified one RCT in patients with asthma.<sup>85</sup> The study found improvements in forced vital capacity (p=0.019) after exercise and at rest (p=0.024),

as well as improved forced expiratory volume ( $p=0.049$ ) at rest; the control group was not specified. However, the included study was in children (outside the scope of this evidence map) and effects on adults are not known.

Two systematic reviews on **menopause** symptoms,<sup>7,49</sup> and one systematic review each on **multiple sclerosis**,<sup>105</sup> **metabolic syndrome**,<sup>24</sup> **PTSD**,<sup>54</sup> older adults with **dementia**,<sup>41</sup> **urinary incontinence** stress in women,<sup>8</sup> and anxiety during pregnancy (**pregnancy-anxiety**),<sup>26</sup> searched for Tai Chi RCTs but did not identify any.

### Most promising areas

In high research volume areas, most promising results across existing reviews were documented for the research areas hypertension, fall prevention outside of institutions, and cognitive performance. However, reviews in all 3 topic areas stated reservations in the conclusions due to the poor quality of the included studies (hypertension, cognitive performance), or conflicting results across outcomes (risk of falling vs rate of falls), comparators (exercise vs non-exercise control groups), and settings (community vs hospitals and care homes).

Statistically significant health effects were also reported for osteoarthritis, COPD, pain, balance confidence, depression, and muscle strength. However, review authors cautioned that the existing evidence is based on insufficient numbers of RCTs and/or poor quality RCTs and is not well equipped to provide definitive answers on the effectiveness of Tai Chi for patient health outcomes.

### VA priority areas

The following provides more detail on the content areas of pain, PTSD, and fall prevention.

#### *Pain*

The outcome pain was the primary focus of 4 systematic reviews.<sup>44,77,102,107</sup> Of the focused reviews, the largest one, published in 2009, identified 7 relevant RCTs. Although all chronic musculoskeletal pain conditions were eligible for inclusion, 6 of the identified studies were in patients with chronic arthritis (osteoarthritis of the hip, knee, lumbar spine, and/or ankle, and rheumatoid arthritis). The seventh included study targeted patients with chronic tension headaches. The individual studies tested Yang-, Sun-, and Wu-style Tai Chi practiced from one to 3 times per week. The intervention duration ranged from 6 to 15 weeks (median 12 weeks). This largest review found a positive effect of Tai Chi on self-reported pain using different assessment scales across studies (MD 10.1 points on a 0 to 100 numerical rating scale; 95% CI 6.3, 13.9; 6 RCTs; comparators not specified).<sup>44</sup> It concluded that Tai Chi has a small positive effect on pain and disability in people with arthritis, but cautioned that the available data are sparse and derived principally from low-quality studies. The review did not address adverse events. A review on self-management strategies to reduce pain and improve function among older adults in community settings (published in 2008) cited the 2004 Cochrane review on rheumatoid arthritis<sup>45</sup> and 2 additional RCTs in osteoarthritis of the knee or lower extremity osteoarthritis. The review indicated that one of the included studies reported a positive effect of Tai Chi compared to usual care (N=72, mean age 64, 12 weeks), while the other one did not (N=33, mean age 68, 12 weeks) and no overall treatment effect estimate was provided.<sup>102</sup> The review did not address adverse

events. A 2007 review on mind-body interventions for chronic pain in older adults included the same 2 Tai Chi RCTs and the synthesis focused on the potential of Tai Chi in preserving function in older adults.<sup>77</sup> The review did not report on adverse events in included studies but concluded that the reviewed mind-body interventions are likely safe. One meta-analysis on core stability exercise versus general exercise for chronic low back pain did not identify any eligible Tai Chi RCTs although Tai Chi studies had been explicitly searched for.<sup>107</sup>

The outcome pain was addressed in 21 included systematic reviews.<sup>6,10,16,23,39,44,45,50,53,55,58,59,72,76,77,81,84,98,102,107</sup> Summary estimates of the size of the effect of Tai Chi on pain across at least 2 RCTs were reported in 5 reviews, including the above discussed review with the primary outcome pain. A 2013 meta-analysis in osteoarthritis reported statistically significant and clinically important effects for pain (SMD -0.45; 95% CI -0.70,-0.20; 7 RCTs) across studies comparing Tai Chi to waiting list, Bingo, attention control programs, routine treatment, self-help programs, or wellness education and stretching.<sup>98</sup> The intervention programs varied from 8 to 24 weeks practicing Tai Chi from oneto 3 times per week. A subgroup analysis showed significant effects on pain and physical function in studies of 12 weeks or fewer but not in studies of longer duration. The authors highlighted that the pain relieving effect is not sustained and that additional studies are needed to investigate the long-term effects of Tai Chi in patients with knee osteoarthritis. The review concluded that 12-week Tai Chi should be included in rehabilitation programs but that the evidence may be limited by potential biases. An earlier osteoarthritis review reported significant positive effects of Tai Chi on pain (SMD -0.79; 95% CI -1.19, -0.39; 6 RCTs). Studies evaluated Yang- or Sun-style Tai Chi, practiced in the majority twice a week (where specified), and the intervention duration ranged between 6 weeks and 6 months. The effects were larger in comparison to attention control groups (SMD -1.18; 95% CI -1.82, -0.54; 3 RCTs) than compared to routine care (SMD -0.47; 95% CI -0.79, -0.14; 3 RCTs); the followup period was not specified. The review cautioned that due to the small number of studies with a low risk of bias, the evidence that Tai Chi is effective in patients with osteoarthritis is limited.<sup>53</sup> The Cochrane review on rheumatoid arthritis did not find statistically significant differences in joint tenderness associated with Tai Chi across 2 studies.<sup>45</sup> A review specific to osteoarthritis of the knee reported significant short-term positive effects for pain intensity (SMD -0.72; 95% CI -1.00, -0.44); 5 RCTs) associated with Tai Chi but not long-term effects, based on 2 studies. The included interventions were described as Yang-style, Sun-style, Tai Chi Qigong, and 12-form Sun-style for arthritis. The weekly frequency of practice varied and the duration ranged from 8 to 48 weeks; some studies included exercises at home after formal instructions ended (instruction time ranged from 8 to 20 weeks). The review highlighted that all positive results represent short-term effects and high quality RCTs are needed to confirm the results.<sup>59</sup>

Of the 21 systematic reviews reporting on the outcome pain, 43% did not address adverse events. Of those reviews that addressed adverse events, one did not report on adverse events in included studies but stated that the analyzed self-management strategies, which included Tai Chi interventions, are not associated with adverse side effects.<sup>102</sup> One review did not report on adverse events in included studies but stated that Tai Chi is likely safe and cited other reviews.<sup>77</sup> Another review that included 2 Tai Chi RCTs stated a lack of adverse events but did not report on individual studies.<sup>76</sup> A large review that included 77 qigong and Tai Chi studies stated that 9 monitored adverse events, and none of these studies reported adverse events.<sup>50</sup> One review reported that 4 out of 9 included RCTs had assessed adverse events, none reported any serious

events, 2 RCTs reported minor muscle soreness and foot and knee pain in the early days of the intervention, one RCT reported increased knee pain and 2 cancer occurrences unrelated to the intervention, and one RCT reported serious adverse events that were not related to the intervention.<sup>53</sup> A review that included 5 Tai Chi RCTs reported that adverse events were assessed in 3 RCTs; 2 were the aforementioned adverse events, while one RCT reported that no adverse events occurred.<sup>59</sup> A review reported that that only 3 out of 8 included Tai Chi RCTs reported safety data; among these, no significant adverse events were reported from participating in a Tai Chi program.<sup>16</sup> One review that included 2 Tai Chi RCTs reported that no serious adverse events were reported.<sup>58</sup> One review reported that no significant adverse events associated with Tai Chi were found.<sup>98</sup> One review included only one Tai Chi RCT; no adverse events were observed in the study.<sup>72</sup> One review addressed adverse events but did not include any Tai Chi RCTs.<sup>107</sup>

The 15 published RCTs currently indexed in PubMed that address the outcome pain in the title or abstract of the citation focused on Tai Chi effects in arthritis, fibromyalgia, immune function, chronic disease, osteopenia, back pain, and diabetes.<sup>112-126</sup> RCTs were published between 2003 and 2013. It is difficult to reconstruct which RCTs would be included in the systematic reviews presented above and whether the pooled results of the meta-analyses would consequently change if the reviews were updated today. The RCTs, including the larger ones with 100 or more participants,<sup>114-118,121</sup> show conflicting results for the effectiveness of Tai Chi compared to diverse control groups.

### *PTSD*

The effects of Tai Chi on PTSD, the second VA priority area, have not been rigorously studied. The earlier described systematic review on mind-body practices for PTSD had searched the databases PubMed/MEDLINE, EBSCO/PsycINFO, and the Published International Literature on Traumatic Stress database in June 2012 for peer-reviewed original journal articles in English evaluating Tai Chi interventions. The review identified one relevant Tai Chi study.<sup>54</sup> The included study was an uncontrolled case series reporting on 4 refugee survivors of torture that had received 10 to 15 minutes of simplified qigong and Tai Chi sessions prior and after psychotherapy sessions.<sup>127</sup> The participants reported looking forward to the sessions and finding them calming and relaxing. The sessions were found to facilitate subsequent psychotherapy sessions, with a decrease in hypervigilance and an increase in introspection observed during psychotherapy. No adverse events or complications related to qigong or Tai Chi were reported.

No studies in combat-related PTSD were identified. The described review and the primary study remain the only citations in PubMed addressing Tai Chi and PTSD. A comprehensive search without language or date restriction in 5 additional databases did not find any additional empirical studies.

### *Fall Prevention*

As shown, fall prevention was the focus of numerous included systematic reviews. Effects of Tai Chi in unselected studies or populations living in the community have been addressed in 10 independent reviews<sup>11,14,38,40,42,43,46,69,71,83,96</sup> and the largest included 15 RCTs. As described above, this large 2010 review reported no statistically significant benefit of Tai Chi compared to non-exercise controls across 5 RCTs and found no changes in effects in subgroup analyses

stratified by setting, intervention dose, and duration of followup. However, a significant pooled estimate on fall rates was found, favoring Tai Chi compared to exercise (IRR 0.51; 95% CI 0.38, 0.68; 2 RCTs).<sup>69</sup> The 2 included RCTs evaluated Yang-style Tai Chi practiced 3 times a week. The authors speculated that the exercise control interventions in the 2 RCTs were possibly comparable with a placebo condition and refuted the interpretation that exercise increases the risk of falls. A Cochrane review on interventions for preventing falls in older people living in the community found no reduction in the rate of falls across 5 RCTs comparing Tai Chi to low level stretching, fall prevention brochure, waiting list, group discussions, or wellness education. However, the review found a significantly reduced risk of falling (RR 0.71; 95% CI 0.57, 0.87; 6 RCTs) associated with Tai Chi group exercises compared to low level stretching, fall prevention brochures, waiting list, wellness education and two not further specified comparators.<sup>42</sup> The interventions were described as Tai Chi Chuan, modified Tai Chi, Sun-style Tai Chi, or Yang-style Tai Chi, practiced from 1 to 5 times per week across studies. The intervention duration ranged from 8 to 52 weeks. The rate of falls was defined as the total number of falls per unit of person time that occurred (*eg*, falls per person year). For risk of falling, the number of fallers was used and the risk ratio compared the number of people who fell once or more (fallers). The treatment effect was greater in the subgroup not selected for higher risk of falling, indicating that Tai Chi appears to be more effective in people who are not at high risk of falling. The AHRQ report on interventions to prevent falls in older adults included Tai Chi studies but did not report a pooled effect estimate.<sup>14</sup> A systematic review on fall prevention that included 6 Tai Chi RCTs gave the pooled estimate for community dwelling studies as RR 0.66 (95% CI 0.52, 0.78) but found no effect of for residential aged-care facility studies.<sup>11</sup> One review found no Tai Chi fall prevention studies of older persons with cognitive impairment; the remaining reviews showed conflicting results across studies and did not provide a pooled effect estimate. A Cochrane review on interventions for preventing falls in older people in care facilities and hospitals included 2 Tai Chi studies; both reported no significant difference in risk of falling.<sup>3</sup> One systematic review specifically addressed effects of fall prevention interventions on depressive symptoms and fear of falling among the aged, not their effects on falls.<sup>87</sup>

The outcome falls was reviewed in 23 of the included systematic reviews.<sup>3,4,10,11,14,34,38,40,42,43,46,50,55,57,68,69,71,81,83,90,91,96,104</sup> Summary estimates for the size of the treatment effect across more than one RCT were reported in 5 reviews. This included the 4 focused meta-analyses described above. In addition, a systematic review and meta-analysis on interventions to improve balance and reduce falls in older adults found no statistically significant results for Tai Chi comparing fall counts across 2 RCTs each, at different followup points.<sup>4</sup>

Of the 23 reviews that reported the outcome falls, 70% did not address adverse events (*ie*, did not report on the presence or absence of adverse events). Adverse events were a secondary outcome in 2 Cochrane reviews on interventions for preventing falls but in one review none of the 6 included Tai Chi RCTs reported on adverse events<sup>42</sup>; in the other, no complications of the intervention (such as sprains, strains, and adverse effects of vitamin D) were reported but the 2 Tai Chi studies were not addressed specifically.<sup>3</sup> As discussed, in a general review that also targeted the outcome falls, only 9 of 77 included qigong and Tai Chi RCTs monitored adverse (these reported none).<sup>50</sup> In a review of the effect of fall prevention exercise programs on fall induced injuries, 6 out of 17 included studies specifically reported the absence of adverse events; the review included 2 Tai Chi studies but did not specify which included studies assessed

adverse events.<sup>38</sup> A review on balance and falls highlighted that one study in participants aged 75 or older showed a negative result; after a 6-month weekly Tai Chi maintenance program, the loss of balance was not significantly changed but the base of support was significantly reduced, indicating a decreased postural stability (sensory organization test).<sup>104</sup> An AHRQ report that included 3 Tai Chi RCTs examined adverse effects of interventions to reduce falls as one of its key questions and reported that one Tai Chi study found increased falls in the intervention group (not statistically significant).<sup>14</sup> One review noted that among frail elderly, the risk to become a faller was significantly increased by the intervention. The review concluded that Tai Chi practice by older adults may only be effective in a more robust older population and may not benefit frail participants. No other adverse effects resulting from Tai Chi participation were identified.<sup>43</sup>

The 14 published RCTs indexed in PubMed and referring to the outcome fall in the title or abstract of the publication addressed interventions designed for older and/or frail elderly, Parkinson's disease, or patients at risk for falls.<sup>128-141</sup> Tai Chi was either the primary focus or only part of the intervention, and fall prevention was the primary focus of some of the studies while others addressed primarily balance improvements. RCTs were published between 1997 and 2013. For 5 of the RCTs<sup>129,131,135,136,141</sup> the latest follow up data were published after the search date of the largest systematic review by Logghe (15 RCTs)<sup>69</sup>, the AHRQ report on interventions to prevent falls in older adults, and the economic evaluation of community and residential aged care falls prevention strategies<sup>11</sup>. Three of these<sup>131,135,136</sup> were published after the last updates of the Cochrane reviews for preventing falls in older people living in the community<sup>42</sup> and interventions for preventing falls in older people in care facilities and hospitals.<sup>3</sup>

## FUTURE RESEARCH

This broad overview of the evidence on Tai Chi concentrated on research on the clinical effectiveness of Tai Chi to improve patient outcomes. It did not consider more refined questions such as the effect of different styles of Tai Chi or the effect of the practitioner's training and skill level. There is some indication that the effectiveness of Tai Chi may depend on setting or patient characteristics as indicated by differential effects of fall prevention in community versus hospitals or nursing homes, as well as the intervention duration (short-term vs long-term), and the comparator (exercise vs non-exercise). The evidence map also indicated that adverse events have not been investigated systematically and is hindered by poor and inconsistent reporting of adverse events.<sup>142</sup> A number of authors have indicated that more research on long-term effects is needed. In addition, across topic areas, reviews concluded that more rigorous research on the clinical effectiveness of Tai Chi is needed.

We identified a large number of clinical indications with unclear evidence. Some reviews included a large number of RCTs, but they addressed very broad topics such as health effects, psychological wellbeing, or interventions targeting older adults and it is likely that effects are outcome- and indication-specific. The outcome balance has also received a lot of research interest but we did not identify a meta-analysis estimating the overall treatment effect; individual study results vary and may be difficult to combine due to a large number of individual tests. The outcome quality of life has also been addressed in a substantial number of trials but no pooled effect estimate exists and effects need to be stratified by comparator given the diversity of the evidence base. Evidence on the role of Tai Chi in chronic conditions, cardiovascular

disease, cancer care, heart disease, cystic fibrosis, infections, stroke rehabilitation, osteoporosis, Parkinson's disease, cardiopulmonary interventions, rheumatoid arthritis, fibromyalgia, and insomnia is very limited due to the small number of published studies. In addition, systematic reviews in menopause, dementia, metabolic syndrome, PTSD, urinary incontinence, multiple sclerosis, and anxiety during pregnancy applications specifically searched for Tai Chi studies, but no RCTs (*ie*, high level of evidence research studies) were identified.

## Ongoing Research

The literature search identified 5 Cochrane review protocols published in the last three years on hypertension,<sup>143</sup> type 2 diabetes,<sup>144</sup> COPD,<sup>145</sup> primary prevention of cardiovascular disease,<sup>146</sup> and improving recovery after stroke,<sup>147</sup> indicating ongoing reviews.

A search of the international registry of systematic reviews PROSPERO identified 4 ongoing registered systematic reviews on Tai Chi: the effect of Tai Chi on hypertension (CRD42014009016), Tai Chi for patients with type 2 diabetes (CRD42014008950), Tai Chi for Parkinson's disease (CRD42013004989), and Tai chi for osteoarthritis (CRD42011001859).

A further 11 registered reviews indicated that Tai Chi interventions are eligible for inclusion in the review: effectiveness of treatment programs aimed at reducing substance misuse among women in prisons (CRD42014009484), supervised exercise on cancer-related fatigue in breast cancer survivors (CRD42014007223), complementary and alternative medicine for lumbar intervertebral disc herniation (CRD42013006876), traditional Chinese exercise for non-communicable diseases (CRD42013006474), physical activity and psychological coping strategies in the management of painful diabetic neuropathy (CRD42013006365), effects of supervised physical activity on cancer related fatigue (CRD42013005803), clinical effectiveness and cost-effectiveness of interventions to prevent postnatal depression (CRD42012003273), effectiveness of physical leisure time activities on glycemic control in adult patients with diabetes type 2 (CRD42012002967), effectiveness of physical leisure time activities on the older adult's physical functioning (CRD42011001571), effectiveness of rehabilitation on physical functioning and quality of life for adults with vertebral osteoporosis or osteopenia (CRD42012002381), and the relationship between the psychosocial impact of osteoarthritis and exercise (CRD42012002963).

## LIMITATIONS

Evidence maps are only a broad overview of the evidence base, indicating areas in which research has been conducted and where more research is needed. Included Tai Chi interventions varied greatly by Tai Chi style, intervention duration, and intervention intensity, and studies varied in their choice of comparator to estimate the effectiveness of Tai Chi. More specific results need targeted systematic reviews (addressing selected clinical indications and outcomes), and effect modifiers should be analyzed in meta-regressions designed to identify sources of heterogeneity. To inform policy and clinical decision making, additional implementation variables are likely to be needed in addition to this broad map of the evidence.

## SUMMARY

Tai Chi has been investigated as a treatment for a number of clinical indications and outcomes. The systematic review of systematic reviews identified 107 Tai Chi systematic reviews. Reviews addressing general health effects, psychological wellbeing, or interventions in older adults included between 31 and 51 Tai Chi RCTs. The topic areas balance, hypertension, falls, quality of life, cognitive performance, and vestibulopathy have also been the focus of research; included reviews identified 10 or more pertinent RCTs per topic. Statistically significant effects pooled across existing studies were reported for hypertension, falls outside of institutions, cognitive performance, osteoarthritis, COPD, pain, balance confidence, depression, and muscle strength. However, review authors cautioned that firm conclusions cannot be drawn due to methodological limitations in the original studies and/or an insufficient number of existing research studies.

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## APPENDIX: PEER REVIEW COMMENTS/AUTHOR RESPONSES

Comment	Response
The effect on pulmonary function causes me to wonder how tai chi would compare to pulmonary rehab programs and also cardiac rehab programs.	We did not identify a summary estimate of the comparative effectiveness of Tai Chi and pulmonary or cardiac rehabilitation programs
This is a rapidly moving field and although this meta-analysis of existing reviews is very comprehensive there will be always studies published right after the completion of a manuscript that could not be taken into account at the time. However, I think several studies have been recently published on the topic of Tai Chi and Parkinson's disease that would be worthwhile to consider in this context (see below).  Tai chi and postural stability in patients with Parkinson's disease. Li F, Harmer P, Fitzgerald K, Eckstrom E, Stock R, Galver J, Maddalozzo G, Batya SS. N Engl J Med. 2012 Feb 9;366(6):511-9.	The RCT is included in the VA priority area section (fall prevention)
A randomized trial of tai chi for fibromyalgia. Wang C, Schmid CH, Roness R, Kalish R, Vinh J, Goldenberg DL, Lee Y, McAlindon T. N Engl J Med. 2010 Aug 19;363(8):743-54.	The RCT is included in the systematic reviews on fibromyalgia <sup>58,76</sup>
Lack of effect of Tai Chi Chuan in preventing falls in elderly people living at home: a randomized clinical trial. Logghe IH1, Zeeuwe PE, Verhagen AP, Wijnen-Sponselee RM, Willemsen SP, Bierma-Zeinstra SM, van Rossum E, Faber MJ, Koes BW. J Am Geriatr Soc. 2009 Jan;57(1):70-5.	We have included the study in the VA priority area section (pain)
What Do We Really Know About the Safety of Tai Chi?: A Systematic Review of Adverse Event Reports in Randomized Trials. Wayne PM1, Berkowitz DL2, Litrownik DE3, Buring JE4, Yeh GY5. Arch Phys Med Rehabil. 2014 May 27. pii: S0003-9993(14)00392-X.	The review was published after the systematic review searches; we have cited it in the future research section
Impact of Tai Chi Chu'an Practice on Balance and Mobility in Older Adults: An Integrative Review of 20 Years of Research. Hackney ME, Wolf SL. J Geriatr Phys Ther. 2014 Jul-Sep;37(3):127-35.	This review was assessed but did not meet inclusion criteria for systematic reviews
J Am Geriatr Soc. 2007 Apr;55(4):511-7. Augmenting immune responses to varicella zoster virus in older adults: a randomized, controlled trial of Tai Chi. Irwin MR(1), Olmstead R, Oxman MN.	The RCT is included in the VA priority area section (pain) and is also included in the systematic review on infections <sup>47</sup>
Psychosom Med. 2003 Sep-Oct;65(5):824-30. Effects of a behavioral intervention, Tai Chi Chih, on varicella-zoster virus specific immunity and health functioning in older adults. Irwin MR(1), Pike JL, Cole JC, Oxman MN.	The RCT is included in the systematic review on infections <sup>47</sup>

<p>The meta-analysis clearly illustrates that there is an urgent need in standardization of methods and reporting in RCTs. However, by the same token it would be helpful if the current meta-review would be clearer in this respect, too. Key elements for the evaluation of effectiveness of an intervention like standardized effect sizes and targeted outcomes are often not clearly or systematically described. For example, when an RCT for Tai Chi in aging is mentioned in the text without ever mentioning what part of aging was targeted as an outcome it leaves the reader with more questions than answers.</p>	<p>It was outside the scope of the project to reanalyze reported data using standardized effect sizes suitable for all included meta-analyses. All available summary estimates were reported but the choice of outcome measure was the individual study and review authors. We have added a sentence to the data synthesis section clarifying that the evidence map was based on systematic reviews as reported by the review authors. We have added the mean age of the participants to the trial description.</p>
<p>The logic for the graphical representation of the data in Figure 2 is sound. However, I am concerned that key issues such as effect size, overall trial duration, frequency and duration of intervention are not reflected.</p>	<p>The bubble plot can only display information on the review level and individual study-level variables are likely to be a mixture which would be difficult to display. We have added more detail on interventions and followup to the VA priority area sections</p>
<p>Also, it is unclear how to interpret a fairly strong trend for effectiveness that is based on 2 studies (Asthma) versus an unclear trend for Health based +50 studies. Isn't there an issue with sampling and noise (due to different methods across studies)?</p>	<p>The unclear trend for broad areas such as health may have to do with the range of outcomes and indications; we have made this more explicit in the text</p>
<p>Would it be possible to give studies a weighting according to their methods and design?</p>	<p>The bubble plot can only display limited information. Adding methods and design information would mean to give up on one of the other dimensions displayed (number of systematic reviews for the indication, number of RCTs in the largest RCTs, or the summary measure of effect. In addition, only very few dimensions can be feasibly assessed on this level (the evidence map is based on more than 100 systematic reviews, many topics included more than one review, each review summarized several individual studies). To address this point, we have added information on the type of review to the synthesis section; <i>ie</i> Cochrane reviews are characterized by methodological rigor, and results from these high quality reviews are highlighted throughout the text summary</p>
<p>PTSD: Although I appreciate the scarcity of studies on the subject it is important to distinguish combat-related PTSD from other forms of PTSD frequently seen in the civilian population.</p>	<p>We have added a sentence highlighting the absence of combat-related PTSD evidence</p>

I feel that phrases like “systematic review of systematic reviews with a scoping review” could be stylistically improved.	The description of the methodology is designed to facilitate the identification of the review in electronic databases (it is standard terminology)
On page 3, 21 “Search”: it would be important to mention your date cut-off for the search in the final version.	We have added the missing search date to the section
For implementation the type of Tai Chi, group size, length of intervention and length of trial (including long-term follow up) would be important factors. However, I am afraid that sadly most studies do not provide that level of detail.	Recognizing the importance of the information we have added more information on the interventions to the VA priority area sections (where possible, the information is limited)
It’s imperative to analyze both sides of the spectrum when reviewing any event, the scientific and experiential, the Yin & Yang, to be able to asses it objectively. Clinical experiential data collected during my years of engagement with GLA VA need to be included for a more rounded, and accurate assessment.	This project is a summary of the published evidence for the VA Evidence-based Synthesis Program; data on clinical experiences would need to be collected in a different project
On Positive Outcomes: These reports need be considered in addition for what they may infer, i.e. .Depression. Chronic emotional states provoke physiological responses, affecting immune and cardio-respiratory function among others.	We are limited in this evidence map to only those outcomes that were reported in the included systematic reviews. We cannot generalize from one outcome to other outcomes. However, all published pooled results have been reported, including physiological responses, immune and cardio-respiratory function
On Inconclusive Outcomes: These should be included only after verifying the studies have fulfilled the requirements of proper scientific and Tai Chi methodology.	The evidence map provides a broad overview of the existing evidence base. Assessing the study quality of each relevant study requires a systematic review focused on a specific clinical condition and outcome and would be a separate project from this evidence map. The reviewer should propose to the ESP leadership that one of the ESP Centers conduct a systematic review for any or all of the conditions in this unclear evidence category for which the reviewer has concerns, <i>eg</i> , a systematic review of Tai Chi effects on Parkinson’s Disease
Outcomes are mainly influenced by the Tai Chi instructional program or method selected and least by the Style. All Tai Chi Styles adhere to the same basic principles.	We have added more information on the intervention program in addition to the Tai Chi style.
Personal Experience: This research summary doesn’t accurately reflect, and in many instances, contradicts my findings in more than 30 years of teaching and practice experience.	We acknowledge the comment; however, the evidence map summarizes current research evidence as reported in systematic reviews and cannot incorporate individual personal experiences

<p>This is my first encounter with the bubble plot style evidence map. It gives a very nice, visual overview of the topic. If there is interest in a specific diagnosis, more detail can be obtained by the executive summary. Although a lot of work was put into this project, I question how much this format will actually help with decision making and implementation. The problem is that this is a review of reviews. This method has the effect of diluting and homogenizing the evidence to the point that it is no longer helpful for decision making. The details really are important, and these can only be found in the original studies. This is particularly true for non-standardized therapies like Tai Chi. We need to know what was done and how they did it to get the outcome they report. This can then help guide implementation of a Tai Chi program. Our facility has done this for the diagnosis for fibromyalgia. When we looked at the original literature, there were some good studies that showed a good positive effect. Their methods seemed similar to what we would offer and based on this we added Tai Chi to the treatment protocol for fibromyalgia. To be sure, there were also less positive studies out there but they were using different protocols. This kind of helpful detail is lost in the review of reviews.</p>	<p>This evidence map is primarily designed to provide a broad overview. However, to address this point we have reworded the abstract and added more detail on those studies that reported positive effects in the VA priority areas to provide more information relevant to clinicians</p>
<p>Under inclusion criteria (p.3, lines 5-7, and 7-11), please clarify. Word usage and parenthesis usage make this section hard to understand.</p>	<p>Edited for clarity</p>
<p>P. 13, lines 15-16: How were “Most promising areas” identified as such?</p>	<p>The section summarizes research areas that reported positive effects across individual studies; we have added more detail to the introductory paragraph</p>
<p>I am a clinician and not a researcher so I am not the most knowledgeable when it comes to the statistical manipulation of data. I do serve on committees that make decisions about clinical implementation. This report seems well done but I’m not sure this format helps with decision making. This format may be more useful with standardized therapies such as medications. Non-standardization has long been the Achilles heel in evaluating the evidence for complementary therapies.</p>	<p>The evidence map format was specifically requested to provide an overview over this broad research field We have expanded the limitation section to acknowledge that additional implementation variables are needed to inform policy and clinical decision making</p>